A DECOUPLING ELEMENT OF DEFORMABLE MATERIAL IN A POWER TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

The invention relates to a decoupling element of deformable material, such as rubber or elastomer, for a rotary drive device such as a pulley, a wheel, etc. in a power transmission system for a compressor, alternator, starter, or any other type of accessory that needs to be driven in rotation.

As shown in the diagrammatic longitudinal and cross-section views of Figures 1 and 1bis, pulleys or other rotary coupling means generally interpose a portion A of annular shape made of rubber having a section that is rectangular or shaped, between a rim B and a central hub C. By deforming in shear, between a rest position K_0 and a position K in rotation, this piece allows a certain amount of angular offset to occur, thereby performing its decoupling function, in particular as a frequency filter and damper between the exciter (arrow E) and the response (arrow R).

The ring A is generally fixed via its inside and outside faces by overmolding or bonding to cylindrical supports made of metal or plastics material and forming respectively the inner hub and the outer rim. It is generally also appropriate to bond the ring to strength members which are themselves force-fitted between the rim and the hub.

That solution, as disclosed for example in patent EP 0 742 377 presents numerous drawbacks, and in particular:

- bonding requires coating and molding operations that are unsatisfactory in terms of cost and harm to the environment due to the use of adhesives and solvents;
- the inserts which are generally made of metal give rise to non-negligible extra cost;
- overmolding implies an additional swaging step to release diff rential stresses by radial deformation, and thus also l ads to extra cost;

- force-fitting th ins rts leads to stresses in th parts; and
- the system cannot b disassembled.

In other documents, for example patent EP 0 793 031, the ring has successive concave and convex undulations of essentially continuous curvature facing complementary shapes made on the hub and the rim. The undulations perform two functions, that of filtering without bonding and that of limiting torque. The concave and convex shapes allow the parts to slip relative to each other beyond a cutoff torque, and also to return to a driving configuration below the cutoff.

That type of solution leads to non-linearity in the torque exerted as angular offset increases, and thus to non-linear stiffness, which is harmful to the filtering function. To be effective filtering must be tuned to specific cutoff frequencies that differ depending on the structure of the system or the type of transmission that is to be provided. However since the system is non-linear, its resonant bandwidth is very broad and filtering is not performed correctly.

SUMMARY OF THE INVENTION

In order to remedy those drawbacks and improve the transfer function of the elastic insert, the invention proposes creating zones in which stresses act essentially in shear in the deformable material so as to implement the power transmission function alone in these zones, independently of any torque limiting effect.

More precisely, the invention provides a decoupling element of deformable material e.g. an elastic material such as rubber or elastomer, for interposing between the faces of two supports of a drive device having a central axis of rotation, the element being formed by a ring comprising a central core and at least two opposite faces. At least one of these faces and the facing face of the support present complementary abrupt projections suitable for meshing together, meshing of the ring creating zones at the roots of the projections where th central core substantially works in shear, these zones being regularly distributed over at l ast one of the faces of the ring.

The central core extends from th protuberance-fre continuous annular portion of the ring.

Under such conditions, the work of the ring is performed by reducing the radial component of the compression which would otherwise become preponderant with increasing angular offset. A linear relationship between torque and offset is then ensured, which leads to constant stiffness over a large angular range, for example a range greater than ±9°, and thus to a narrow resonant band.

In particular embodiments:

- the two opposite faces of the ring and the facing faces of the supports are fluted, or else only one face of the ring and the facing face of the support are fluted, the non-fluted face of the ring and the facing face of the support being bonded together, possibly via a linking insert;
- the faces of the ring and of the supports that mesh are cylindrical and parallel to the axis of rotation and/or radial and perpendicular to said axis, the projections being respectively radial and/or axial;
- the projections are of constant or linearly varying profile so as to facilitate unmolding and assembly by self-centering when engaging the ring on the supports;
- the projections are crenellations of right section, i.e. having side flanks that are substantially perpendicular to the face of the ring on which they are formed;
- the projections present side flanks of section that flares going away from said face, with a mean angle of up to 60° relative to the radius, being of trapezoidal shape, or hyperbolic shape, with suitable curvature and advantageously of tapering shape to facilitate unmolding or assembly by self-centering when engaging the free ring on the supports;
- when the two opposite cylindrical faces are parallel to the axis of rotation of the ring and carry opposite radial projections, the square of the ratio of the radii of the opposite cylindrical faces is inversely equal to the ratio of the angles at the center intercepting two projections on respective faces, the opposite projections being periodically distributed in a

basic pattern so as to xert sh ar stresses over th ntire ring that are constant and that are rev rsible on g ing from one direction of rotation to the other;

- the ring is split to form an opening so as to make assembly easier during insertion of the hub by expanding the ring, and during its own insertion into the rim by compressing the ring, thereby compensating for play between the parts.

The ring of the invention may be made by molding, by extrusion followed by cutting up or slicing into "washers", or by injection/compression. In some cases, the material is made flat and then rolled up and cut to shape in order to make split rings.

The present invention comes more generally within the context of a power transmission system including a torque limiter or breaker for the purpose of stopping drive in the event of jamming, and a rotary drive device including the decoupling element.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described below in greater detail in non-limiting manner by describing embodiments with reference to the accompanying drawings, in which:

- Figures 1 and 1bis (described above) are diagrammatic section views of a prior art ring of deformable material;

- Figures 2a and 2b are fragmentary section views of decoupling rings of constant profile, with teeth respectively of right profile and of flared profile, the rings being mounted between two complementary supports, and the figures illustrating diagrammatically the shear behavior of rings of the invention;

- Figure 3 is an exploded view of an embodiment of a drive device including a decoupling ring and supports of right and constant profile for a radial assembly;

- Figures 4a and 4b are axial and longitudinal section views on A-A and B-B showing the Figure 3 assembly once assembled;

- Figure 5 is an explod d view showing a variant having a split ring;
- Figure 6 is an exploded view showing a variant having a ring and supports of varying profile for self-centering purposes;
- Figure 7 is an exploded view of an embodiment of a drive device having a ring with axial projections formed on its opposite radial faces;
- Figures 8a and 8b are perspective views seen from two different angles showing an example of a ring having both radial and axial projections;
- Figures 9a and 9b are axial and longitudinal section views on A-A and B-B showing a drive device of the invention including the ring of Figures 8a and 8b; and
- Figure 10 is an exploded view of an embodiment of a drive device of the invention including a ring having radial projections in the form of cylindrical studs.

DETAILLED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown diagrammatically in the fragmentary section of Figure 2a, an example of a cylindrical decoupling ring 2 of the invention comprises a continuous annular central core 1 (outlined within the ring by dashed lines in the figure) and abrupt projections 2e, 2i extending radially from the side flanks 22a and projecting at right angles in this example.

The projections respectively referenced 2e and 2i are regularly distributed in alternation respectively on the outside face 21e and on the inside face 21i of the ring in particular in order to conserve good uniformity in mass distribution. A section of ring defined by a pair of successive projections, an inside projection and an outside projection, thus forms a basic pattern which is repeated around the ring so as to form cylindrical crenellated faces.

The ring m shes between two supports c mprising a central hub 3 and a rim 4 presenting faces 31 and 41 that face the compl mentary

faces 21i and 21i of th ring. Th rim and th hub are made of metal or of plastics material in the example shown, while th ring is made of rubber. The ring may be obtained by combining an elastomer material with a metal reinforcing insert, or a plurality of materials or a single elastomer material of different densities:

- a density for the core which is subjected to shear and which imparts stiffness;
- a density for the outer projections, advantageously including textile reinforcement to reinforce contact and combat wear; and
- a density for the inside projections, with textile reinforcement being optional.

In a second example shown diagrammatically in Figure 2b, the side flanks 22b of the projections 20e and 20i are radially flared away from the central core 1. The projections present an "hourglass" shape in section of trapezoidal form, with a mean flare angle α_3 that may be as much as 60°, as shown.

In operation, power transmission is localized at the roots of the projections 2e and 2i and takes place for the most part in the shear zones K_1. Because of the blocking obtained by the right or inclined side flanks, compression remains secondary.

In addition, the section of the projections is dimensioned by ratios appropriate for the sections in the working zones so as to limit bending and thus put the central core into compression, thereby enhancing work in shear, with work in compression becoming negligible.

With radial projections, the square of the ratio of the radii of the cylindrical faces 21e and 21i $(R1/R2)^2$ is advantageously substantially equal to the inverse of the ratio of the angles at the center intercepting two projections 21e and 21i on respective faces (α_2/χ_1). This dimensioning causes the shear stresses K_1 exerted on the ring as a whole to be made uniform and constant, said stresses being located mainly at the roots of the proj ctions. This dimensioning also makes th shear rev rsible wh n going from one direction of rotation to the other.

Th xploded vi w of Figure 3 and th s ction views of Figures 4a and 4b show an example of a driv d vice 10 for a motor v hicl compressor. This device comprises a cylindrical decoupling ring 2 of right and constant profile together with a central hub 3 and a rim 4 forming supports with complementary profiles that are right and constant. These elements correspond to the elements shown in Figure 2a for making a radial assembly.

The hub 3 presents a central gear 30 for driving the shaft 50 (Figures 4a and 4b) of the alternator about an axis X'X. The face 31 of the hub is provided with projections 3e of right and constant profile that are complementary to recesses 22i formed between pairs of projections 2i on the face 21i of the ring 2. The rim 4 has a wall 42 presenting on its face 41 projections 4i and intervening recesses 44i for engaging respectively with the recesses 22e and the projections 2e on the face 21e of the ring.

Assembly is performed by sliding the ring between the support parts. The parts need to be finely indexed depending on the desired amount of play by using any known indexing means (optical, mechanical, etc.).

The height, i.e. the depth, of the fluting is a function of the power level of the torque to be transmitted, and also of their particular shape. By way of example, this height may lie in the range 1 mm to 5 mm.

A small amount of radial play may be retained between the parts due to manufacturing tolerances. If this is acceptable for the rim and the hub, the play can be zero with the ring then being assembled with a small amount of pressure, without that preventing disassembly.

Once assembled, the above assembly presents the appearance shown in axial and longitudinal section in Figures 4a and 4b. The rim 4 is centered by a strength member 45 mounted on a tube via bearings 46.

In a variant shown in an exploded view in Figure 5, the ring 2a is split. Th op ning 5 formed in this way makes assembly easi r by enabling it to be open d out while th hub 3 is being inserted and by nabling it to be

compressed whil it is being inserted in the rim 4, thereby enabling play between said parts to be comp nsated. Th spreading forces exerted by the hub on the ring are compensated by the compression exerted by the rim on said ring. Once assembly is completed, no play remains between the parts.

In order to make split rings, the part can be molded directly or else it can be made flat by injection/compression, and then rolled up to obtain a cylindrical part having the desired opening, after which it can be dispensed by slicing.

In another variant, shown in exploded view in Figure 6, the projections 2'e and 2'i of the ring, and the complementary projections 3'e and 4'i respectively of the hub 3' and of the rim 4' have side flanks 22' of right radial projection, but of axial profile that varies along the axis X'X.

In this example, the axial variation in the profiles is linear so as to form projections of axial profile that is trapezoidal. Under such conditions, during assembly, the short bases B1 of the trapezoidal profiles, e.g. 2'e, are placed facing the large bases B2 of the recesses, e.g. 44'i, into which they are to be engaged: self-centering adjustment then takes place between the projections and the recesses while they are being mutually engaged. The parts can then be assembled together while taking less care with indexing. Under such circumstances, molding is preferable, nevertheless extrusion is also possible with the fluting being re-machined after slicing.

The presence of varying profile and also of appropriate tapers also makes it easier to perform unmolding during manufacture of the ring.

The example shown in Figure 7 relates to an embodiment of the cylindrical drive device that includes a ring 200 with axial projections 202 and 203 formed on its opposite radial faces 212 and 213.

In this example, the faces 212 and 213 of the ring, the face 212 of the central hub 300, and the face 413 of the rim 400 that engage mutually are radial and perpendicular to the axis of rotation X'X. The projections 202 and 203 on the ring, the projections 302 on the hub, and the proj ctions 403 on the rim ext nd axially.

With reference to the perspective views of Figures 8a and 8b, there can be seen an example of a ring 240 having projections that are both radial and axial: radial projections 24i and 24e formed on the opposite axial faces, respectively the inside face 25i and the outside face 25e, are combined with axial projections 262 and 263 formed on the opposite radial faces respectively referenced 272 and 273. Overall, this combined solution uses a quantity of material to make the projections that is equivalent to the quantity used when making radial projections or axial projections alone, given that the sections of the projections in the combined technique can be, very approximately, about half size.

In the example shown, the projections are right and of constant profile, however the various sections and profiles described above can also be applied to them. As before, the projections alternate around the ring so as to conserve a central core of constant thickness and a balanced distribution of masses and of shear stresses.

The ring 240 with combined radial and axial projections is coupled to a hub 340 and to a rim 440 presenting complementary projections 342 and 443, as shown in the axial and longitudinal sections of Figures 9a and 9b. The assembly forms a drive device 11 of the invention. These figures also include elements shown in Figures 4a and 4b that are equivalent respectively thereto, having the same reference symbols: the rim 440 is centered by a strength member 45 mounted on a tube via bearings 46.

The exploded view of Figure 10 shows a variant embodiment of the drive device 12 comprising a ring 280 having radial projections in the form of cylindrical studs 282 and 283 that are respectively formed in alternation on the opposing cylindrical faces 292 and 293 of the ring 280. The hub 380 and the rim 480 present respective notches 383 and 483 for receiving the studs.

The invention is not limited to the embodiments described and shown. It is possible to make the ring out of a deformable plastics material, polypropylene, polyethylene, or polyamide, or out of a composite material of the thermoplastic elastomer (TPE) type.

It is also possible to conserve an insert, and to use fluting for the outsid face where th diameter makes it possibl to retain m r fluting. Meshing can be implemented on a single pair of facing faces between the ring and the rim or between the ring and the central hub, with the other pair of facing faces being bonded together.

The invention is applicable to any drive device including a filter, damping, or absorber element. By way of example, the accessories which are driven in rotation can be any component of an engine or of a transmission of a motor vehicle.